Kingcome TSA inventory audit

Introduction

The Ministry of Forests conducts an inventory of each timber supply area (TSA) in British Columbia every 10 to 30 years—using standards and procedures developed by the Resources Inventory Program. Regular updates are undertaken to reflect changes in the timber volume due to growth and to depletions from harvesting and natural causes.

This report presents the results of an inventory audit performed within the Kingcome TSA. Located on northern Vancouver Island, the adjacent mainland, and small islands between the mainland and Vancouver Island, the Kingcome TSA is in the Vancouver Forest Region and is administered from the Port McNeill Forest District office in Port McNeill. The TSA covers over 1.126 million hectares. The topography varies considerably, from rolling terrain with flat valley bottoms on northern Vancouver Island to the rugged mountains and steep-sided inlets on the mainland coast.

Purpose of the audit and application of the results

It is often asked, "How accurate is the current inventory?" To answer this important question, the Ministry of Forests has developed an inventory audit methodology specifically designed to test the overall accuracy of estimates of the total standing volume in each timber supply area.

This inventory audit methodology entails sampling three primary components of the inventory: mature forests, immature forests, and non-forest areas.

The objective of the inventory audit program is to help identify TFLs or TSAs where the forest inventory needs attention. Enough samples are taken to ensure statistically reliable results for the TSA as a whole.

The amount of data collected, however, is not sufficient to make statistically reliable conclusions about specific areas or tree species. For example, any overall differences highlighted by the audit could result from problems with one tree species, from part of the land base (such as high elevation rather than lower elevation areas), from one age group of forest stands, or from a combination of these and other factors. As a consequence, general audit results cannot appropriately be used to adjust information about the forests currently available for timber harvesting since this area constitutes only a portion of the total forested area in the TSA.

The audits provide information that may be useful to the Chief Forester when determining the allowable annual cut—offering a general assessment of the uncertainty associated with mature timber volumes, immature site index, and the non-forest classification. However, the audit results cannot justifiably be used to make specific adjustments to growth and yield and other information used in timber supply analyses and allowable annual cut determinations.

Methods

Current inventory

There are 37 TSAs in British Columbia, varying in size from approximately 70 000 hectares to 13 million hectares. Inventories of each TSA are conducted through a multistage process. Polygons are first delineated from 1:15 000-scale aerial photographs. Photo-interpretation is then used to produce data on a number of attributes for each polygon. These attributes include species composition, stand height, age, and crown closure. Timber volume is then estimated indirectly using the photo-interpreted variables and an empirical yield model.

To keep estimates current, inventories are regularly updated to account for forest growth and for depletions due to harvesting, fire, and the impact of insects and disease damage. Empirical yield models, such as the Ministry of Forests Variable Density Yield Prediction (VDYP) computer model, are used to update the inventory for forest growth. Field visitation, satellite imagery, and aerial photographs may be used to update the inventory for depletions.

Inventory audit procedures

The inventory audit tests three components of the current inventory. The first component is the mature forested areas (forest stands older than 60 years). The inventory audit tests the accuracy of the mature timber volume. The second component tested is immature stands (younger than 60 years but older than the silvicultural classification of free growing). The audit tests the accuracy of the site growth potential (site index) assignment for these stands. The third component tested is the area classified as non-forest in the inventory, which includes areas such as lakes, gravel pits, and alpine meadows. The audit tests the accuracy of the photo-interpreted classification for this component.

Mature component assessment criteria

To test the mature component of the inventory, the existing inventory's estimate of the mean mature volume per hectare for the TSA (*the inventory volume*), is compared with a new estimate of the mean mature volume per hectare obtained from the audit samples (*the audit volume*).

The difference between these two estimates is called the total bias. A test is conducted on this bias to determine if it is statistically significant. This test establishes whether there are detectable differences between the audit volume estimate and the inventory volume estimate, for the total forested area of the TSA.

If the total bias is found to be statistically significant, further analyses are conducted to determine if the specific source of bias within the inventory is one of the following:

- *classification bias:* This is caused by incorrectly estimating the polygon attributes; or
- *model bias:* This is caused by poor prediction from the yield model, which was developed for large areas of the province and was not designed for specific management units.

The analysis to determine the source of bias uses an estimate of the mean mature volume per hectare for the TSA called the *ground attribute volume*. This is calculated from audit sample attributes (stock and stand table estimates of species composition and stocking, and ground-based averages of top height and age), along with crown closure taken from the original map label, using the yield prediction model. The difference between the ground attribute volume estimate and the audit volume estimate approximates the bias associated with the yield model. The difference between the audit volume estimate and the inventory volume estimate not accounted for by the model bias approximates the bias associated with the inventory classification attributes. Once the source is identified, further analyses may be done on the inventory classification attributes or the yield model itself.

Immature component assessment criteria

Accuracy of the inventory classification for immature stands is tested by examining the site index assignment. Since the immature forest stand site index provides an estimate of site productivity, its accuracy affects the projection of long-term harvest levels.

Data gathered is examined to determine how closely the audit and inventory site indices match for individual samples, and to explore potential trends.

Non-forest component assessment criteria

The audit test for the non-forest component of the inventory assesses the accuracy of the non-forest classification assignment. An airphoto interpreter certified by the Ministry of Forests compares the non-forest inventory classification to a suitably scaled forest cover aerial photograph. Classification accuracy is rated using a point scoring scheme to determine an overall accuracy percentage. The acceptance criteria for this test is 85% or higher.

Kingcome TSA audit sampling procedures

The Kingcome TSA sample used updated maps based on an inventory originally conducted between 1961 and 1974. The majority of the inventory was completed in 1974. A list of all polygons identified on these maps was produced and sorted on a number of stand characteristics (site quality, age, and species group). Polygons were systematically selected from this list by a process designed to produce a representative sample of the TSA.

For the mature forested component of the inventory audit, a random sample of 50 forested polygons from

the total forested area in the TSA was selected for sampling.

Up to 4 full-measure prism plots and 5 count plots were established within each of the 50 sample polygons. The plots were located systematically, using a square grid and a random start point. The grid interval varied with polygon size. To reduce sample costs for large or irregular polygons, only a randomly selected portion of the polygon was sampled. Not all plots could be established within each sample polygon. Some plots were dropped due to steep and unsafe conditions or time constraints. The Ministry of Forests determined that no significant bias was introduced by dropping these plots. Field data collection and compilation followed Ministry of Forests cruising and cruise compilation procedures. The objective was to obtain audit volumes that were comparable (in terms of utilization standards and merchantability definitions) to the inventory volumes produced from the VDYP computer yield model.

The VDYP system produces net merchantable volume per hectare defined as stem volume inside bark of all live trees excluding a 10-cm diameter inside-bark top, a 30-cm-high stump, and decay (as estimated from Ministry loss factors). Dead potential and veteran trees are not included in the VDYP estimates. This volume is calculated for a utilization standard defined as all live trees of 17.5+ cm dbh. When considering the audit results, it should be noted that there are some differences between the utilization standards applied in the audit and those used operationally.

The audit volume estimates were then compared to the inventory volume estimates (from VDYP) to test the validity of the current inventory. A paired-sample *t-test* was used to test for significant differences. The precision of the inventory volume estimates – how well each inventory volume estimate corresponds to the audit volume estimate on a sample-by-sample basis – was assessed by measuring the statistical correlation. The data was then post-stratified to detect trends related to the operable and inoperable forested land base distribution of the sampled polygons.

From the immature forested component, a random sample of 20 polygons was selected for sampling. Up to 6 inventory ground calls were established within each of the 20 sample polygons.

The plots were located along a single transect line that was considered representative of the site productivity (site index) of the stand. A total of about 120 ground calls were established and data collection followed the standard Ministry of Forests inventory ground call procedures. The location of the sample transect was subjective. Since the magnitude of bias caused by this process is unknown, the reported results and their interpretations for the immature forested component should be used with caution.

To audit the non-forest component, a random sample of 30 non-forest polygons was selected. Standard Ministry of Forests inventory airphoto classification techniques were used to compare the 30 non-forest polygon classification assignments to corresponding airphoto checks.

Inventory audit results

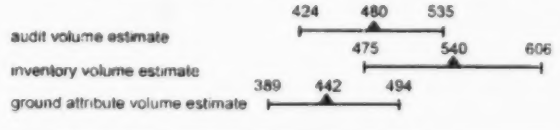
Analysis of mature volumes

The results of the inventory audit for mature volume statistical analyses at the 17.5+ cm dbh utilization limit for the total forested area are given in Table 1.

TABLE 1: Statistics for the audit volume, inventory volume, and ground attribute volume estimates at 17.5+ cm dbh utilization (net decay), Kingcome TSA

	Audit Volume Estimate	Inventory Volume Estimate	Ground Attribute Volume Estimate
Number of samples	50	50	49
Mean (m^3/ha)	480	540	442
Coefficient of variation (%)	41	43	42
Standard error	27.6	32.5	26.2
Sampling error (%)	11.6	12.1	11.9
95% confidence interval (m^3/ha)	424–535	475–606	389–494
Correlation coefficient r = 0.637			
Ratio of means (audit/inventory volume): 0.89			

Bar graph representation of 95% confidence intervals (in m^3/ha)



The correlation coefficient of 0.637 for the audit and inventory estimates indicates a strong relationship among the individual samples. There is a 60 m^3/ha difference between the mean inventory estimate for mature volume (540 m^3/ha) and the audit estimate (480 m^3/ha). A paired-sample *t-test* determined that this difference is statistically significant, 19 times out of 20. The 95% confidence interval for the mean paired differences is -113 to -9 m^3/ha.

Since there is a statistically significant difference between the two estimates, the ground attribute volume was calculated using the VDYP model. Top height was not available for one sample; therefore the ground attribute volume estimates are based on 49 samples. The estimated mean ground attribute volume is 442 m^3/ha.

The difference between the mean ground attribute volume (442 m^3/ha) and the mean audit volume (482 m^3/ha, based on the matching 49 samples) is 40 m^3/ha. The difference between the mean inventory volume (540 m^3/ha) and the mean ground attribute volume is 98 m^3/ha. This suggests that a significant bias associated with the inventory attributes is being partially compensated for by a smaller model bias in the opposite direction.

Due to the difficulty in providing reliable estimates of the volume of dead potential and veteran tree timber in the provincial inventory, this component has been excluded from past provincial inventory estimates. In the Kingcome TSA, dead potential and veteran trees represent a significant volume. The issue of dead potential and veteran trees is currently under review within the context of utilization and biodiversity policy issues.

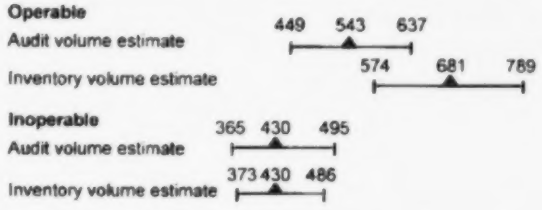
Analysis of operable and inoperable volumes

To provide audit results more likely to be applicable to the timber supply planning process, an approximation was made of the forested areas considered currently available for timber harvesting (operable areas). The audit results were post-stratified based on this approximation. The results of the inventory audit for samples in the operable forested areas in the TSA are given in Table 2.

TABLE 2. Statistics for the audit volume and inventory volume estimates at 17.5+ cm dbh utilization (net decay), for the operable and inoperable forested areas, Kingcome TSA

	Operable		Inoperable	
	Audit Volume Volume	Inventory Volume Estimate	Audit Volume Volume	Inventory Volume Estimate
Number of samples	22	22	28	28
Mean (m^3/ha)	543	681	430	430
Coefficient of variation (%)	39	35	39	34
Standard error	45.3	51.6	31.8	27.7
Sampling error (%)	17.4	15.7	15.2	13.2
95% confidence interval	449–637	574–789	365–495	373–486
Correlation coefficient	$r = 0.574$		$r = 0.648$	
Ratio of means (audit/inventory)	= 0.80		= 1.00	

Bar graph representation of 95% confidence intervals (in m^3/ha)



For the 22 samples located within the operable forested area, the mean audit volume is 543 m^3/ha and mean inventory volume is 681 m^3/ha. The difference between these two estimates (138 m^3/ha) is statistically significant, 19 times out of 20. However, due to the small sample size, these conclusions must be viewed with caution.

For the 28 samples located in inoperable forested area, the mean audit volume was 430 m^3/ha and the corresponding inventory volume was also 430 m^3/ha.

Analysis of immature inventory classification

Out of 20 stands sampled in the field, the inventory correctly identified site index within ±5 m of the audit site index for 12 stands; the inventory site index was more than 5 m lower than the audit site index for 4 stands, and more than 5 m higher for 4 stands.

Analysis of non-forest inventory classification
Thirty stands classified as non-forest were assessed for accuracy of the inventory. The resulting score is 84%, which does not meet the provincial minimum standard of 85%.

Discussion and conclusions

The objective of the inventory audit in the Kingcome TSA was to assess the overall accuracy of the current (1961 to 1974) Ministry of Forests inventory. The mature, immature, and non-forest components were tested.

The results of the audit for the mature component of the inventory suggest that the inventory volume is over-estimated. When the data was post-stratified, a similar bias was observed in the operable forested area. Potential biases in the VDYP yield model and the inventory classification attributes will be examined further.

Audit results for the immature component of the inventory suggest an acceptable level of accuracy for site index assignment in young stands.

The audit assessment of the non-forest classification in this TSA indicates that it does not meet provincial standards. This is largely the result of minor misclassification of alpine forest types. Results indicated that the issue of non-forest classification accuracy in this TSA had no impact on the forested area available for timber harvesting reported in the timber supply analysis. Deficiencies in the non-forest classification will be addressed in the new vegetation inventory.

Glossary

accuracy: A measure of how close an estimate is to the true value.

allowable annual cut: The rate of timber harvesting specified for an area of land.

analysis unit: The basic building blocks around which inventory data and other information are organized for use in forest planning models, typically involving specific tree species or type groups that are further defined by site class, geographic location or similarity of management regimes.

bias: The quality of a measurement device or procedures that tends to result in a systematic misrepresentation of what is being measured.

coefficient of variation: A relative measure of variation within a population, calculated as the ratio between the standard deviation and the mean value.

confidence interval: The range of values within which the population parameter is expected to lie.

confidence level: The estimated probability that a population parameter lies within a given confidence interval.

correlation coefficient: A measure of the relationship between two variables. A value of 0 for the correlation coefficient indicates a random relationship, whereas a value of ±1 indicates a perfect positive or negative linear correspondence.

dead potential trees: Standing or down dead timber which is estimated to contain at least 50% of its original gross volume in sound wood content.

diameter at breast height (dbh): The stem diameter (outside-bark) of a tree measured at breast height (1.3 metres above the point of germination) to the nearest millimetre.

field visitations: Ground-level field procedures designed to provide physical verification of polygon inventory attributes.

free-growing (crop): A crop of healthy trees of a commercially valuable species, the growth of which is not impeded by competition from plants, shrubs, or other trees.

inoperable lands: Lands that are unsuited for timber production now and in the foreseeable future because of their topography, inaccessible location, low value of timber stands, or designation for uses incompatible with timber production.

mean: The average value of a set of observations.

polygon: A portion of land area, delineated on mid-scale aerial photographs, of "like" or uniform land cover type.

pre-inventory assessments: Inventory activities to evaluate the existing forest inventory as a basis for deciding whether to re-inventory or update the current inventory, and to document the existing

inventory, maps, and photos to support the execution of the reinventory or update if required.

public sustained yield units (PSYU): A portion of a TSA; an area of Crown land, usually a natural topographic unit determined by drainage areas, managed for sustained yield by the Crown through the Ministry of Forests. It includes all Crown lands within the currently established boundaries of the unit and excludes federal lands, provincial parks, experimental forest reserves, gazetted watersheds and tree farm licences.

ratio estimate: The ratio between two different estimates.

representative: The quality of a sample having the same characteristics as the population from which it is selected.

sampling: The process of selecting observations.

sampling error: The error attributed to sampling procedures.

significant difference: The results of a statistical test comparing either two or more estimates, or an estimate to a fixed value. If the difference is too large to be attributed to chance, the difference is said to be statistically significant.

site index: An expression of the forest site quality of a stand, at a specified age, based either on the site height, or on the top height, which is a more objective measure.

standard error: An expression of the absolute variability of an estimate.

standard deviation: A measure of the variation of the population.

timber supply analysis: An assessment of future timber supplies over long planning horizons (more than 200 years) by using timber supply models for different scenarios identified in the planning process.

timber supply area (TSA): An area defined by an established pattern of wood flow from management units to the primary timber-using industries.

tree farm licence (TFL): Privately managed Sustained Yield Units; designed to enable owners of Crown-granted forest lands and old temporary tenures or the timber licences which replace them, to combine these with enough unencumbered Crown land to form self-contained sustained yield management units.

variable density yield prediction (VDYP) model: An empirical yield-prediction system for natural stands based on data collected in temporary inventory sample plots (TSPs) and natural, permanent growth sample plots (PSPs). VDYP predicts volume (net decay) and diameters at four utilization levels using stand height, age, and density. The aerial approach uses crown closure as the density measure.

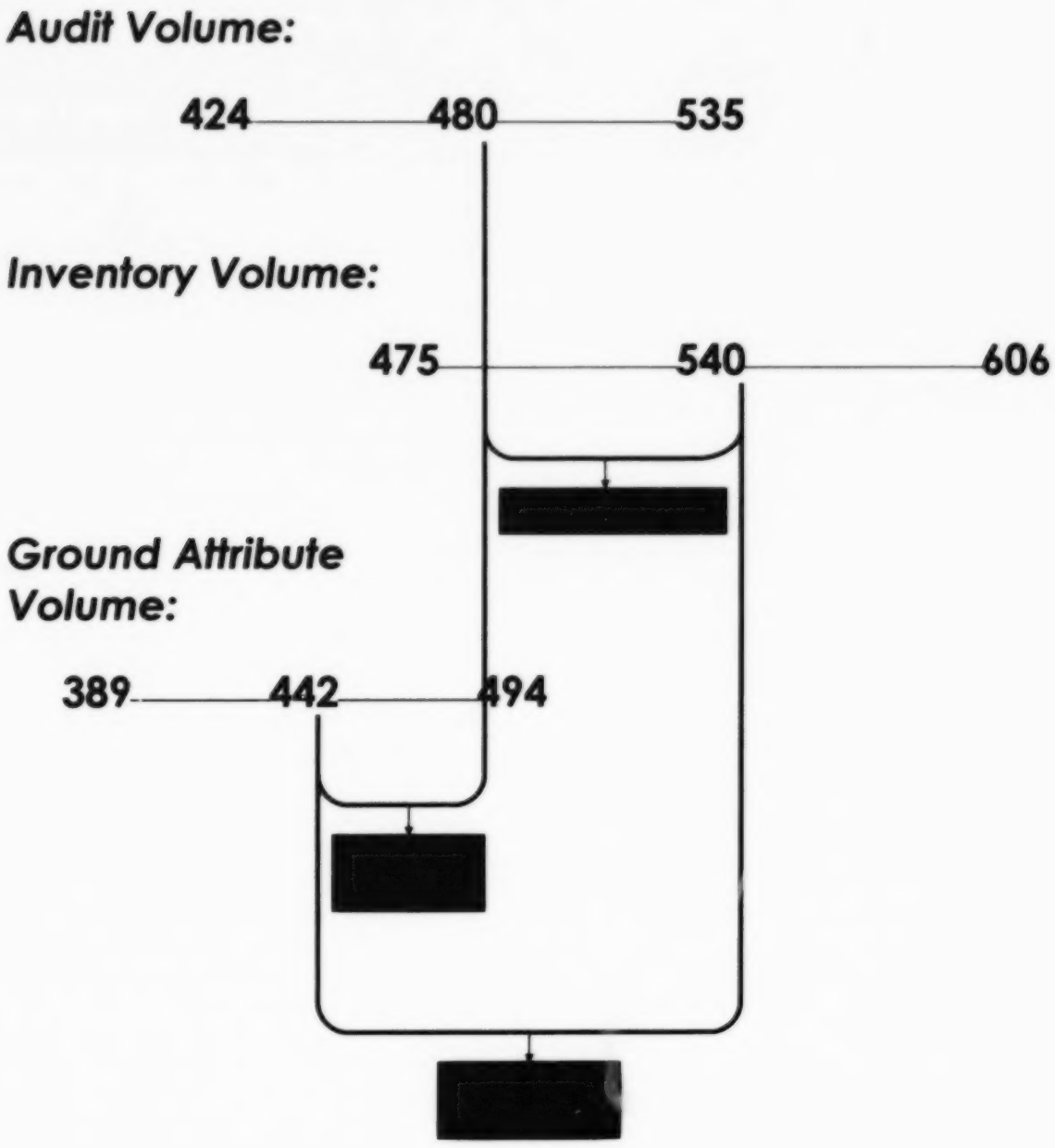
veteran trees: Mature living trees which are remnants of an older stand.

For more information

For more information or to obtain other inventory audit reports, contact: Director, Resources Inventory Branch, 722 Johnson Street, Victoria, B.C., Canada V8W 3E7, 250-387-1314, fax 250-387-5999. Visit our web site at http://www.for.gov.bc.ca/resinv/homepage.htm

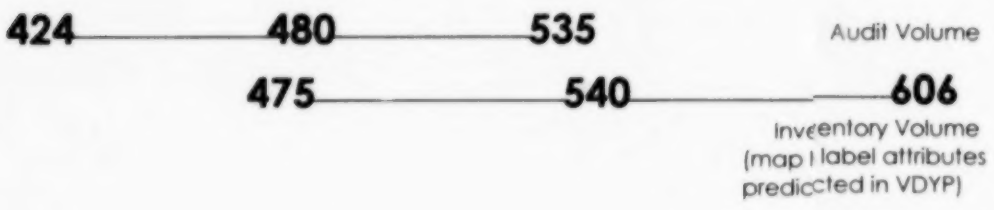
October 1997

Inventory Audit Results :
Overview Kingcome TSA
February, 1996



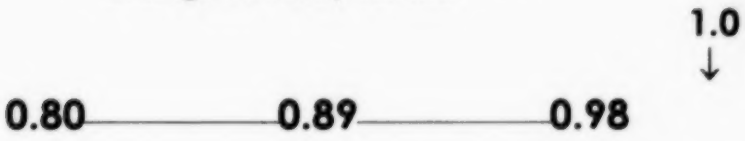
Audit Volume (Kozak) vs. Inventory Volume (Predicted in VDYP)

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 17.5 cm + net merch. less decay only/Kozak/Tree Class 1,2))*



2. Ratio Analysis : Ratio of Means @95%

$R = \frac{\text{average audit volume}}{\text{average inventory volume}} = 0.89$



* *Since 1.0 is outside the interval, the ratio indicates that there is a significant difference between the audit volume and the inventory volume.*

3. Paired T Test @ 95% (α=0.05) for all sample polygons
   mean difference = -60.89 m^3/ha
   p - value for mean difference = 0.023
   since p-value < α, the difference is significant

4. Paired T Test @ 95% for all sample polygons by map label GTG
   There was a significant difference for GTG E.
   (for GTG E: mean difference = -70 m^3/ha; p - value = 0.019; n=39)

5. Correlation @ 95% (α=0.05) for all samples
   Correlation co-efficient r = 0.637
   p value for correlation co-efficient < 0.001
   ∴ correlation is significant

KINGCOME TSA Inventory Audit:
Audit Volume vs. Inventory Volume (by GTG)
(Tree Class 1 & 2, less decay only, 17.5cm + dbh)

Letter symbols correspond to map label GTG's as follows:

E	*C, CF, CH*
F	*H (and Hpl), H Deciduous*
G	*HF,HC,HB,HS*
H	*B,BH,BS*
L	*pure Pl*

Audit Volume (Kozak) vs. Inventory Volume (Predicted in VDYP) for samples in the OPERABLE forested area (n=22)

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 17.5 cm + net merch. less decay only/Kozak/Tree Class 1,2)*

449 ——— 543 ——— 637 Audit Volume

574 ——— 681 ——— 789
Inventory Volume
(map label attributes predicted in VDYP)

2. Ratio Analysis : Ratio of Means @95% for the operable forested area

$R = \frac{\text{average audit volume}}{\text{average inventory volume}} = 0.80$

1.0
↓

0.67 ——— 0.80 ——— 0.92

* *The ratio indicates that there is a significant difference between the audit volume and the inventory volume in the operable forested area.*

3. Paired T Test @ 95% (α=0.05) for the operable forested area
mean difference = -138.67 m^3/ha
p - value for mean difference = 0.006
**since p-value < α, the difference is significant*

4. Paired T Test @ 95% for the operable forested area by map label GTG
There was a significant difference for GTG E.
(for GTG E: mean difference = -192 m^3/ha; p - value = 0.005; n=13)

5. Correlation @ 95% (α=0.05) for the operable forested area
Correlation co-efficient r = 0.574
p value for correlation co-efficient = 0.005
∴ correlation is significant

KINGCOME TSA Inventory Audit:
Audit Volume vs. Inventory Volume (by GTG)
for samples in the OPERABLE forested area
(Tree Class 1 & 2, less decay only, 17.5cm + dbh)

Letter symbols correspond to map label GTG's as follows:

E	*C, CF, CH*
F	*H (and Hpl), H Deciduous*
G	*HF,HC,HB,HS*
H	*B,BH,BS*
L	*pure Pl*

Audit Volume (Kozak) vs. Inventory Volume (Predicted in VDYP) for samples in the INOPERABLE forested area (n=28)

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 17.5 cm + net merch. less decay only/Kozak/Tree Class 1,2)*

365 ——— 430 ——— 495 Audit Volume

373 ——— 430 ——— 486 Inventory Volume

(map label attributes predicted in VDYP)

2. Ratio Analysis : Ratio of Means @95% for the inoperable forested area

$R = \frac{\text{average audit volume}}{\text{average inventory volume}} = 1.00$

1.0

↓

0.88 ——— 1.00 ——— 1.12

* *Since 1.0 is within the interval, the ratio indicates that there is no significant difference between the audit volume and the inventory volume in the inoperable forested area.*

3. Paired T Test @ 95% (α=0.05) for samples in the inoperable forested area.
mean difference = 0.23 m^3/ha
p - value for mean difference = 0.993
**since p-value > α, the difference is not significant*

4. Paired T Test @ 95% for samples in the inoperable forested area by map label GTG.
There were no significant differences within any of the GTGs.

5. Correlation @ 95% (α=0.05) for samples in the inoperable forested area.
Correlation co-efficient r = 0.648
p value for correlation co-efficient < 0.001
.: correlation is significant

KINGCOME TSA Inventory Audit:
Audit Volume vs. Inventory Volume (by GTG)
for samples in the INOPERABLE forested area
(Tree Class 1 & 2, less decay only, 17.5cm + dbh)

Letter symbols correspond to map label GTG's as follows:

E *C, CF, CH*
F *H (and Hpl), H Deciduous*
G *HF,HC,HB,HS*
H *B,BH,BS*
L *pure Pl*

Audit Volume (Kozak) vs. Ground Attribute Volume (Predicted in VDYP): *"VDYP model" bias*

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 17.5 cm + net merch. less decay only/Kozak/Tree class 1,2))*

425——————**482**——————**538** Audit Volume (n=49)

389——————**442**——————**494** Ground Attribute Volume (n=49) (predicted in VDYP)

2. Ratio Analysis : Ratio of Means @95% (n=49; top height data unavailable for one sample)

$$R = \frac{\text{average audit volume}}{\text{average ground attribute volume predicted in VDYP}} = 1.09$$

1.0
↓
1.00——————**1.09**——————**1.18**

** Since 1.0 is within the interval, the ratio indicates that there is no significant difference between the audit volume and the ground attribute volume.*

3. Paired T Test @ 95% ($\alpha = 0.05$) for all sample polygons (n=49)
mean difference = 40.13 m^3/ha
p - value for mean difference = 0.036
**since p - value < α, the difference is significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG
There was a significant difference within GTG E.
(for GTG E: mean difference = 48 m^3/ha; p - value = 0.013; n=38)

5. Correlation @95%($\alpha = 0.05$) for all samples (n=49)
Correlation co-efficient r = 0.768
p - value for correlation co-efficient < 0.001
∴ correlation is significant

KINGCOME TSA Inventory Audit:
Audit Volume (Kozak) vs. Ground Attribute Volume (Predicted in VDYP) by GTG
(Tree Class 1 & 2, less decay only, 17.5cm + dbh)

Letter symbols correspond to map label GTG's as follows:

E	*C, CF, CH*
F	*H (and Hpl), H Deciduous*
G	*HF,HC,HB,HS*
H	*B,BH,BS*
L	*pure Pl*

Ground Attribute Volume (predicted in VDYP) vs. Inventory Volume (predicted in VDYP): *"Attribute" Bias*

1. Average volumes/ha and confidence interval @ 95%
(Utilization level : 17.5 cm + net merch. less decay only)

389 ——— 442 ——— 494 Ground Attribute Volume (n=49)

473 ——— 540 ——— 607
Inventory Volume (n=49)

2. Ratio Analysis : Ratio of Means @ 95% (n=49; top height data unavailable for one sample)

$$R = \frac{\text{average ground attribute volume (VDYP)}}{\text{average inventory volume (VDYP)}} = 0.82$$

1.0
↓

0.74 ——— 0.82 ——— 0.90

** The ratio indicates there is a significant difference between the ground attribute volume predicted in the VDYP and the inventory volume predicted in the VDYP.*

3. Paired T Test @ 95% ($\alpha = 0.05$) for all sample polygons (n=49)
mean difference = -98.61 m^3/ha
p - value for mean difference < 0.001
**since p - value < α, the difference is significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG
There was a significant difference within GTG E.
(for GTG E: mean difference = -115 m^3/ha; p - value < 0.001; n=38)

5. Correlation @95%($\alpha = 0.05$) for all samples (n=49)
Correlation co-efficient r = 0.693
p - value for correlation co-efficient < 0.001
.: correlation is significant

KINGCOME TSA Inventory Audit:
Ground Attribute Volume (Predicted in VDYP) vs. Inventory Volume (Predicted in VDYP) by GTG
(Tree Class 1 & 2, less decay only, 17.5cm + dbh)

Letter symbols correspond to map label GTG's as follows:

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F	*H (and Hpl), H Deciduous*
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H	*B,BH,BS*
L	*pure Pl*

Audit Volume (Kozak, tree class 1,2,3&5) vs. Inventory Volume (Predicted in VDYP, tree class 1&2)

1. Average Volumes/ha and Confidence Interval @ 95% *(Utilization level : 17.5 cm + net merch. less decay only; Tree Class 1,2,3&5 for audit volume; Tree class 1,2 for Inventory (VDYP) volume)*

511 —— **568** —— **625** Audit Volume

475 —— **540** —— **606** Inventory Volume (map label attributes predicted in VDYP)

2. Ratio Analysis : Ratio of Means @95%

$$R = \frac{\text{average audit volume}}{\text{average inventory volume}} = 1.05$$

1.0
↓

0.95 —— **1.05** —— **1.15**

* *Since 1.0 is within the interval, the ratio indicates that there is no significant difference between the audit volume and the inventory volume.*

3. Paired T Test @ 95% (α=0.05) for all sample polygons
mean difference = 27.43 m^3/ha
p - value for mean difference = 0.307
**since p-value > α, the difference is not significant*

4. Paired T Test @ 95% for all sample polygons by map label GTG
There were no significant differences within any of the GTGs.

5. Correlation @ 95% (α=0.05) for all samples
Correlation co-efficient r = 0.626
p value for correlation co-efficient < 0.001
∴ correlation is significant

KINGCOME TSA Inventory Audit:
Audit Volume (Tree Class 1,2,3&5) vs. Inventory Volume
(by GTG) ***(less decay only, 17.5cm + dbh)***

Letter symbols correspond to map label GTG's as follows:

E	*C, CF, CH*
F	*H (and H Pl), H Deciduous*
G	*HF,HC,HB,HS*
H	*B,BH,BS*
L	*pure Pl*

Audit Volume (Kozak, tree class 1,2,3&5) vs. Inventory Volume (Predicted in VDYP, tree class 1&2) for samples in the OPERABLE forested area (n=22)

1. Average Volumes/ha and Confidence Interval @ 95% for the operable forested area *(Utilization level : 17.5 cm + net merch. less decay only; Tree Class 1,2,3&5 for audit volume; Tree class 1,2 for Inventory (VDYP) volume)*

545 ——— 636 ——— 727 Audit Volume

574 ——— 681 ——— 789

Inventory Volume
(map label attributes predicted in VDYP)

2. Ratio Analysis : Ratio of Means @95% for the operable forested area

$$R = \frac{\text{average audit volume}}{\text{average inventory volume}} = 0.93$$

1.0
↓

0.81 ——— 0.93 ——— 1.06

* *The ratio indicates that there is no significant difference between the audit volume and the inventory volume in the operable forested area.*

3. Paired T Test @ 95% (α=0.05) for samples in the operable forested area
mean difference = -45.01 m^3/ha
p - value for mean difference = 0.297
**since p-value > α, the difference is not significant*

4. Paired T Test @ 95% for samples in the operable forested area by map label GTG
There were no significant differences within any of the GTGs.

5. Correlation @ 95% (α=0.05) for samples in the operable forested area
Correlation co-efficient r = 0.621
p value for correlation co-efficient = 0.002
∴ correlation is significant

KINGCOME TSA Inventory Audit:
Audit Volume (Tree class 1,2,3&5) vs. Inventory Volume (by GTG) for samples in the OPERABLE forested area
(less decay only, 17.5cm + dbh)

Letter symbols correspond to map label GTG's as follows:

E	*C, CF, CH*
F	*H (and Hpl), H Deciduous*
G	*HF,HC,HB,HS*
H	*B,BH,BS*
L	*pure Pl*

Audit Volume (Kozak, tree class 1,2,3&5) vs. Inventory Volume (Predicted in VDYP, tree class 1&2) for samples in the INOPERABLE forested area (n=28)

1. Average Volumes/ha and Confidence Interval @ 95% for the inoperable forested area *(Utilization level : 17.5 cm + net merch. less decay only; Tree Class 1,2,3&5 for audit volume; Tree class 1,2 for Inventory (VDYP) volume)*

443 ——— 514 ——— 585

Audit Volume

373 ——— 430 ——— 486

Inventory Volume
(map label attributes as predicted in VDYP)

2. Ratio Analysis : Ratio of Means @95% for the inoperable forested area

$R = \frac{\text{average audit volume}}{\text{average inventory volume}} = 1.20$

1.0
↓

1.04 ——— 1.20 ——— 1.35

* *Since 1.0 is outside the interval, the ratio indicates that there is a significant difference between the audit volume and the inventory volume in the inoperable forested area.*

3. Paired T Test @ 95% (α=0.05) for samples in the inoperable forested area.
mean difference = 84.35 m^3/ha
p - value for mean difference = 0.010
**since p-value < α, the difference is significant*

4. Paired T Test @ 95% for samples in the inoperable forested area by map label GTG.
There was a significant difference for GTG E.
(for GTG E: mean difference = 68 m^3/ha; p - value = 0.0035; n=26)

5. Correlation @ 95% (α=0.05) for samples in the inoperable forested area.
Correlation co-efficient r = 0.535
p value for correlation co-efficient = 0.003
∴ correlation is significant

KINGCOME TSA Inventory Audit:
Audit Volume (Tree class 1,2,3&5) vs. Inventory Volume (by GTG) for samples in the INOPERABLE forested area
(less decay only, 17.5cm + dbh)

Letter symbols correspond to map label GTG's as follows:

E	*C, CF, CH*
F	*H (and Hpl), H Deciduous*
G	*HF,HC,HB,HS*
H	*B,BH,BS*
L	*pure Pl*

Inventory Classification Assessment

- 84% of the growth type groups* from the inventory (ie. map labels) matched the audit growth type groups.
- the growth type group distribution for the 50 inventory audit samples is as follows (the bold italic entries on the diagonal in the table indicate a GTG match between the audit and the inventory):

Audit GTG (rows)	***Inventory GTG (columns)***						
	B	E	F	G	H	L	*total*
B	***0***	0	0	0	0	1	1
E	0	***37***	0	4	0	0	41
F	0	0	***1***	1	0	0	2
G	0	2	0	***3***	0	1	5
H	0	0	0	0	***1***	0	1
L	0	0	0	0	0	***0***	0
total	0	39	1	8	1	2	**50**

Letter symbols correspond to GTG's as follows:

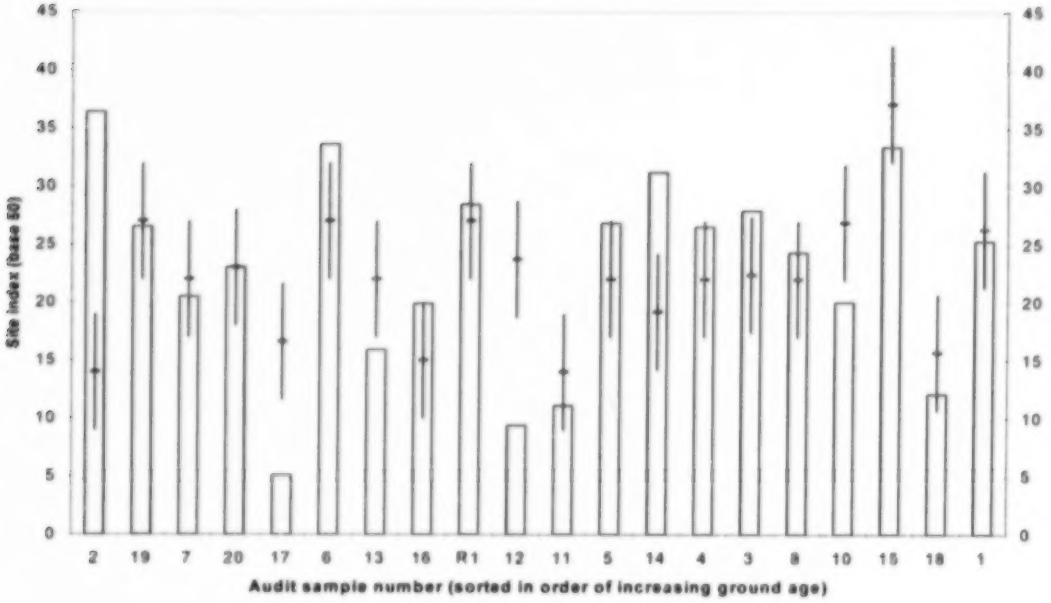
B	*FC, FCy, FH, FS*
E	*C, CF, CH*
F	*H (and Hpl), H Deciduous*
G	*HF,HC,HB,HS*
H	*B,BH,BS*
L	*pure Pl*

* *As generated by VDYP.*

Immature Site Index and Classification Assessment

- 35% of the growth type group assignments from the inventory (ie. map labels) matched the corresponding audit growth type group assignment.

KINGCOME TSA Inventory Audit:
Comparison of Inventory and Audit Site Index
for Immature Samples



Notes:

- shaded bars correspond to ***audit site index*** values
- tick marks on vertical lines represent ***inventory site index*** (vertical lines have arbitrarily been set at ±5m around site index)
- audit site indices based on BH age where available (using Freddie)
- inventory site indices from FIP file
- the inventory site index was within 5m of the audit site index for 12 samples (the inventory SI was more than 5m higher than the audit SI for 4 samples and more than 3m lower than the audit SI for 4 samples)

Non-forest Classification Assessment

- an assessment of the non-forest inventory assignment resulted in a score of 83.6% in the Kingcome TSA (the provincial minimum standard is 85%)
- a summary of the non-forest classification assessment is attached